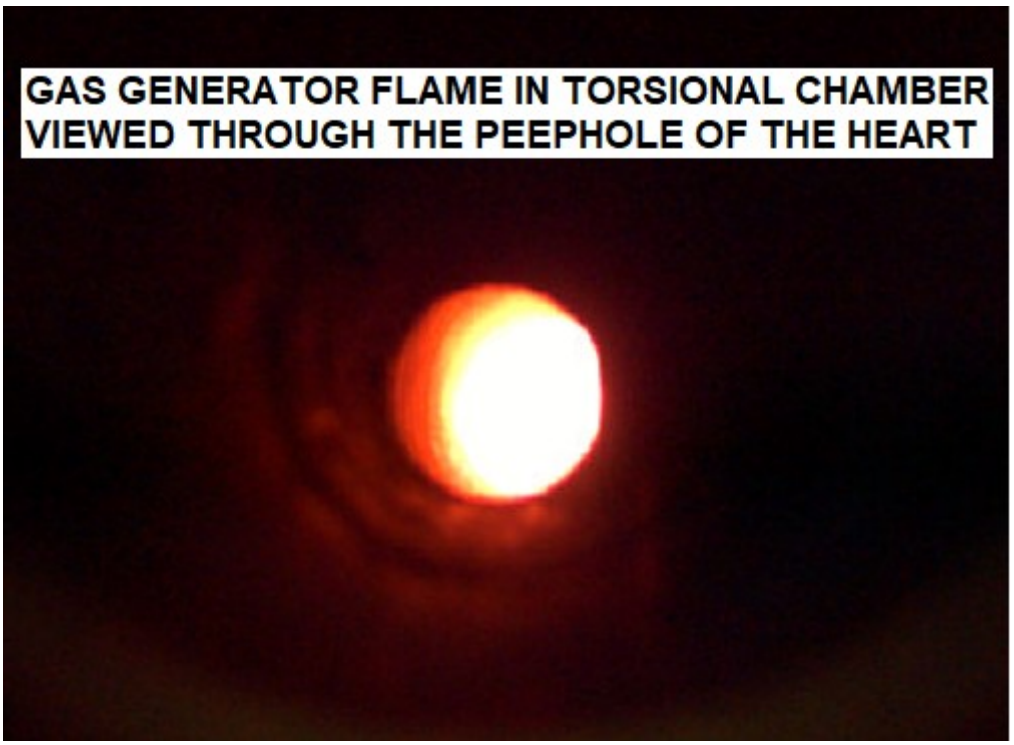
CHAPTER 5: Operation Part 4

WOOD GASIFIER BOILERS



The gas generator must be lit with greater care than direct combustion. All the precautions noted above must be taken, in addition to the fact that we have primary combustion and then the gas produced must be burned in a secondary combustion, separate from the first, in the boiler's combustion chamber.

First, the gas generator is lit by operating the draft. Initially, combustion inside the gas generator will be complete with very little gas formation (there is an excess of air inside the gas generator due to the relatively rapid initial combustion).

Next, you will see that the temperature of the gases entering the boiler's combustion chamber begins to rise (indicating that the gasification volume is becoming significant). Subsequently, as the primary air (and the wood load) increases, the gas composition (CO and other gases) also increases.

At this point, a pilot light should be lit in the boiler's combustion chamber (generally using bottled gas or an auxiliary oil burner). By slowly introducing secondary air, a stable secondary flame is

established between the gas produced by the gas generator and the supplied secondary air (generally slightly heated if the boiler is warm, or cooled if it is cold). **Initially, the flame will be very unstable: little gas and cool air, with a tendency to produce pulsations.**

In some gas generators, although there is secondary combustion, because the connection between the boiler and the gas generator is of large section and short passage, the secondary combustion is actually an extension of the primary combustion, and in these cases the presence of pilot flames is not necessary.

The secondary flame can be checked through the sight glasses. Initially, a lot of "dirty" gases are noticeable in the chimney, but these will disappear (as the temperature of the gases entering the secondary combustion chamber increases, the flame stabilizes).

Secondary air regulation should be done using instruments or by observing a faint, pale bluish flame, ensuring it doesn't reach the bottom of the combustion chamber.

Upon entering the flue pipes, the flame is extinguished, quickly fouling them, raising the chimney temperature, and restricting gas flow within a few days.

The amount of secondary air will be related to the amount of primary air (according to the boiler's vaporization requirements).

The amount of wood loaded into the gasifier must be regulated by its height and the temperature of the gases as they exit the gasifier (since this reflects the height of the "bed" of wood chips or short logs above the "grate").

The temperature will decrease with an overload (very rich gas), or rise momentarily when the wood "bed" is lowered to a certain value.

The temperature will also decrease due to insufficient fuel for gasification.

Perfect gasification would produce approximately 1/3 of the heat

available inside the gasifier.

The ash bed should not be allowed to sag, as this generates high temperatures (due to the high air velocity locally). **The ashes should not be completely removed, as this can damage the grates** (the rotating support).

The secondary flame must be constantly monitored, and if it needs to be extinguished, it must be reignited by piloting, slowly restoring the secondary air supply; otherwise, explosions or an unstable flame will occur in the home.

In some cases, a pilot flame is not necessary (reignition can be done directly from the gas generator).

Combustion is regulated by both **primary and secondary air, and the amount of wood must** be taken into account, as any of the three elements can affect optimal performance.

The greater the combustion requirement, the more gases are needed—increasing the primary air—to burn in the firebox with more secondary air.

TEMPERATURE, FLAMMABILITY LIMITS, AND FLAME SPEED OF GASES:

IGNITION TEMPERATURE IN AIR:

Hydrogen ... 580-590°C (1076-1094°F)
Methane ... 650-750°C (1202-1382°F)
Ethane ... 520-630°C (968-1166°F)
Carbon Monoxide ... 644-658°C (1191-1216°F)
Gas Oil ... 336°C (637°F)
Ordinary Coal ... 400-425°C (752-797°F)

FLAMMABILITY LIMITS IN AIR:

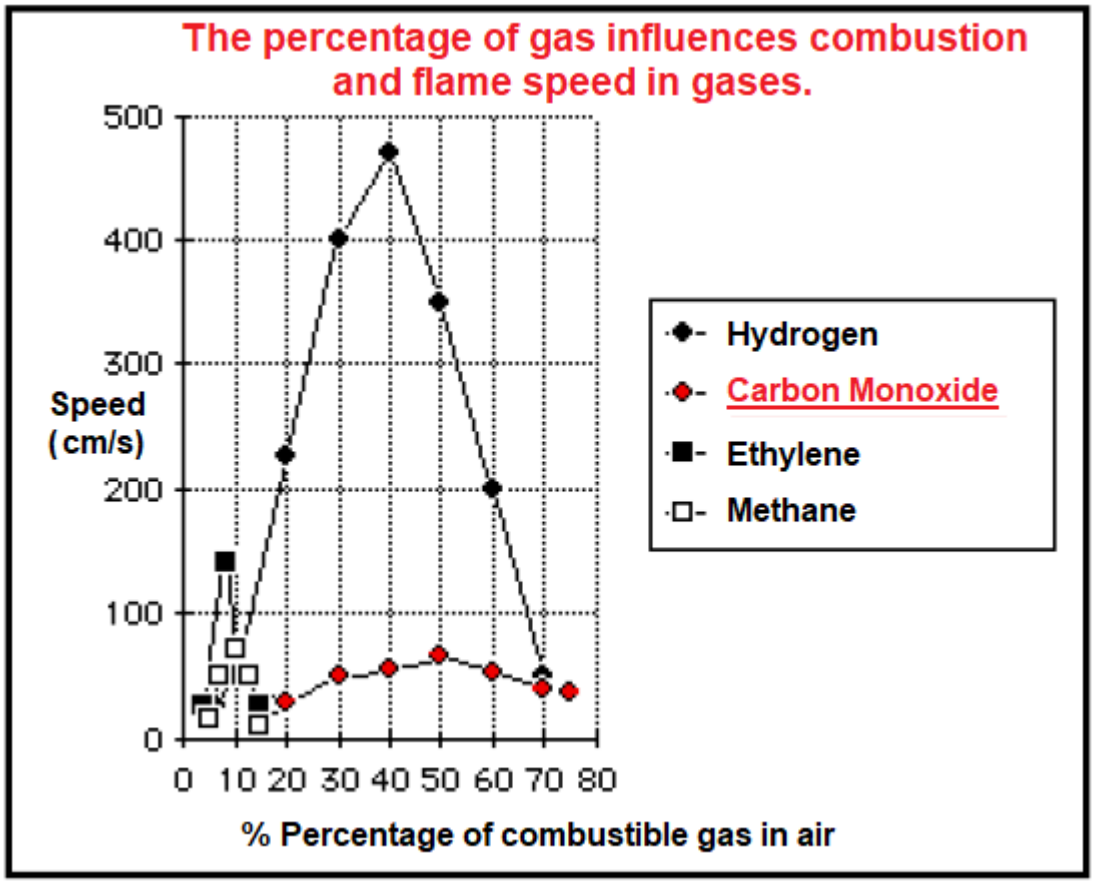
Lower Limit and Upper Limit %

Coal Gas ... 5.3% - 31%
Benzene ... 1.4% - 7.5%
Help Furnace Gas ... 35% - 74%
Carbon Monoxide ... 12.5% - 74%
Hydrogen ... 4% - 75%
Methane ... 5% - 15%

Since the wood in the gasifier is transformed into a gas at a variable temperature between 400°C and 700°C (depending on the wood load and the amount of primary air circulating among the wood, with little heat transfer within the gasifier itself), **we must consider that burning a gas is not as easy as it initially seems.**

For ignition to occur, minimum and maximum conditions must be met (and each gas has a combustion rate also related to these parameters).

In gasifier operation, factors such as the **height of the wood, its quality (including moisture, rot, bark, etc.), and the ratio of primary to secondary air in the combustion chamber play a fundamental role**.

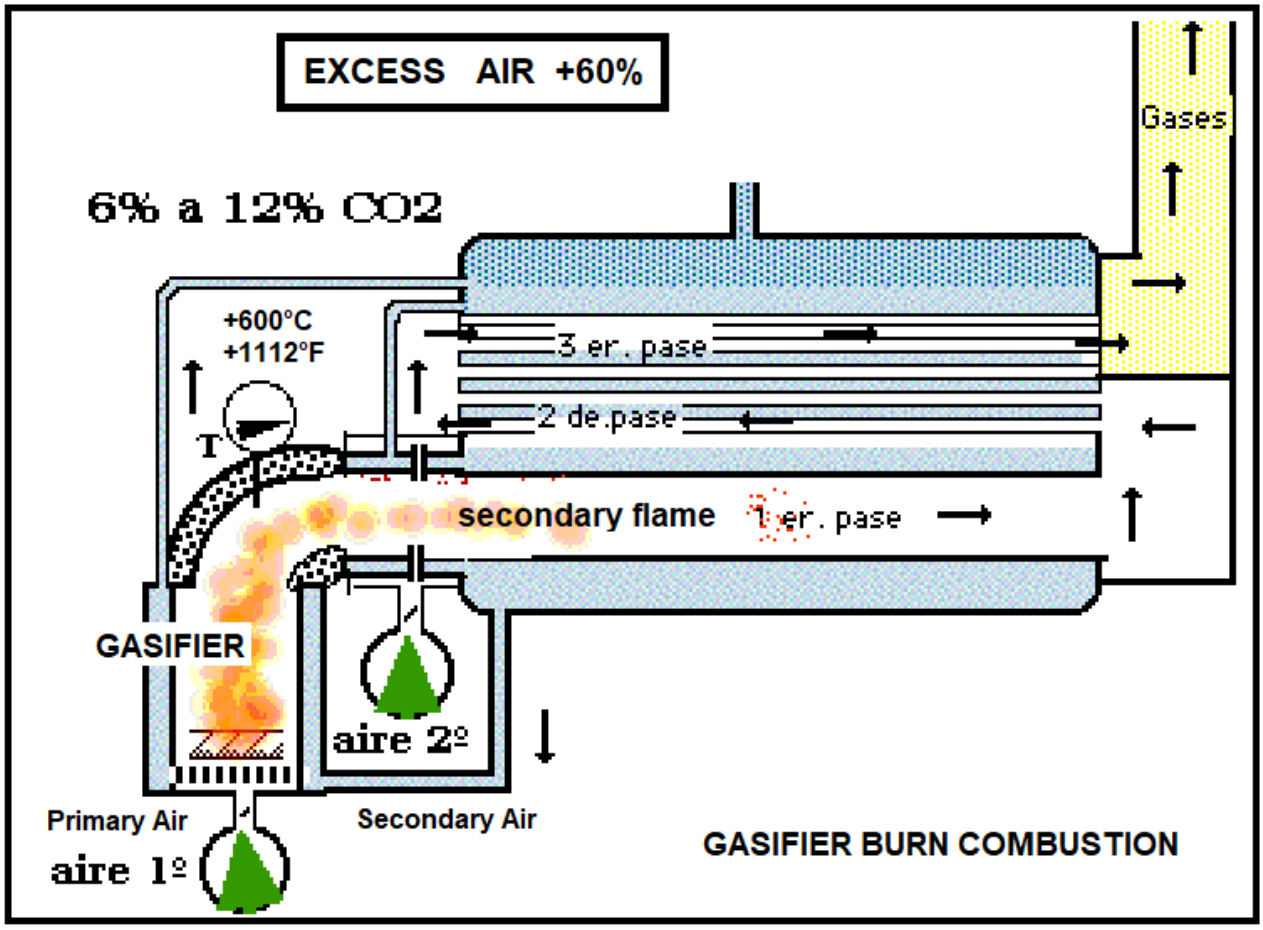


THE COMBUSTION RATE OF CO (carbón monoxide) IS LOW AT ANY CONCENTRATION

As we can see in the graph above, the combustion rates of the different gases vary with their concentration, with the lowest rate corresponding to CO (carbon monoxide). As it cools and its percentage in the gas mixture decreases, its combustion tends to slow down.

It exits through the chimney as a polluting loss if combustion is not achieved inside the combustion chamber (hence the importance I place on having an O2 and "unburned gases" meter in the chimney to ensure, as technically as possible, that combustion is complete).

Regulation of combustion by wood gas generator:

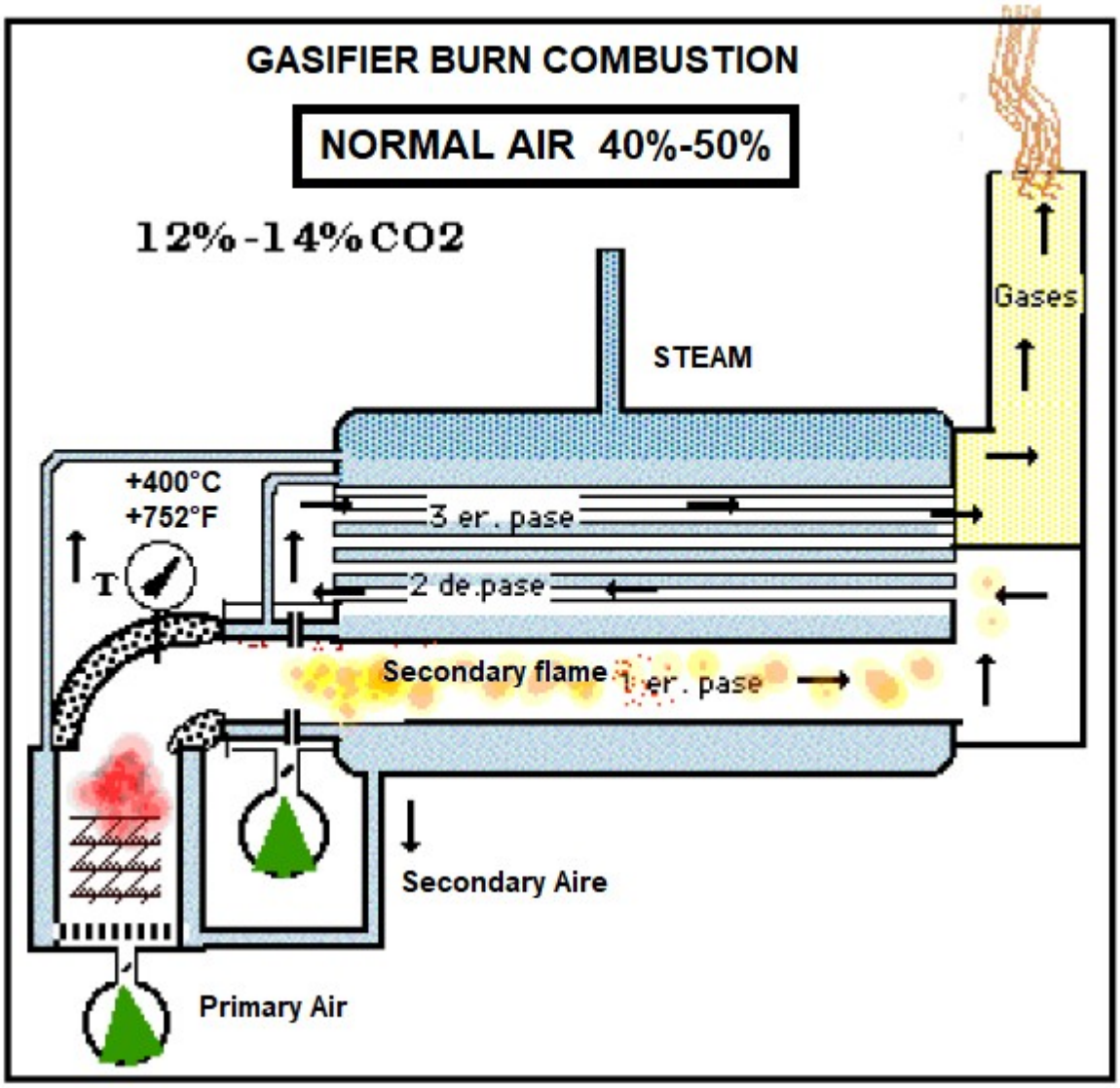


1-Excess air:

The secondary flame is very short, there is a luminous flame inside the gasifier, CO2 is less than 12%, and O2 is more than 8%.

There is no smoke in the chimney, and the temperature of the combustible gases is high (if there is sufficient wood in the gasifier).

When using instruments to measure flue gases, it is advisable to use an Ostwald triangle for wood to verify that the readings close at a "point": this confirms that the measurement is correct.



2-Good Combustion:
In this case, there is no smoke, the secondary flame reaches almost the end of the boiler's combustion chamber (although the very end of the flame is nearly impossible to observe), the gasifier charge is correct (height), the flue gas temperature is at an intermediate value, CO2 is above 14%, O2 is below 6%, **and there should be no unburned gases present (CO% equal to zero).**

Monitoring the flame in practice is difficult due to the lack of light during secondary combustion, so considerable operational experience is required to achieve these values.

It is affected by the general conditions we have given for firewood, but the moisture content of the firewood is less tolerable (it is advisable not to work with firewood with more than 30% moisture, and to use clean eucalyptus firewood, preferably without bark).

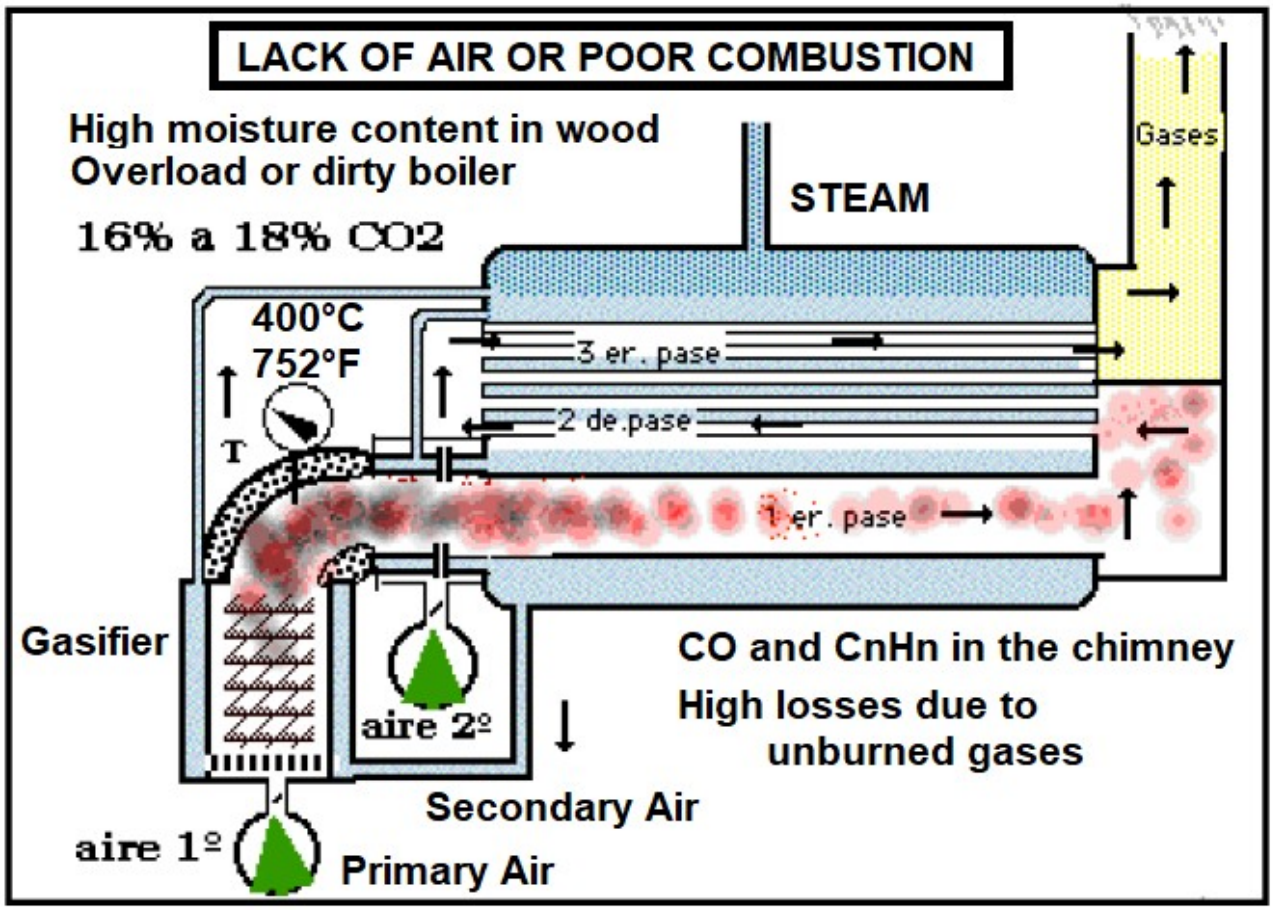
3- Lack of air:

In this case, some **whitish smoke is noticeable** (sometimes blackish if the lack of air is severe), CO2 is above 16%, O2 is less than 3.5%, and there is a **presence of unburned gases** (CO, accompanied by volatiles and tars that tend to dirty the boiler and corrode the metal chimney: cold areas).

The secondary flame appears dirty and very long (touching the rear sight glass).

The most common cause of this situation is the lack of air regulation and the wood load: overloading, wood moisture, wood quality (dirty wood, excessive bark, etc.), and a dirty boiler.

This situation causes the boiler to become dirty within a few days and lose vaporization and combustion capacity (due to insufficient gas transfer and passage; this is noticeable by a sharp rise in the chimney temperature, which lowers the boiler's efficiency).



4-Poor Combustion:

In this case, despite the total amount of air being correct, due to adjustments, complete combustion is not achieved, leaving unburned gases that are detected in the chimney (CO).

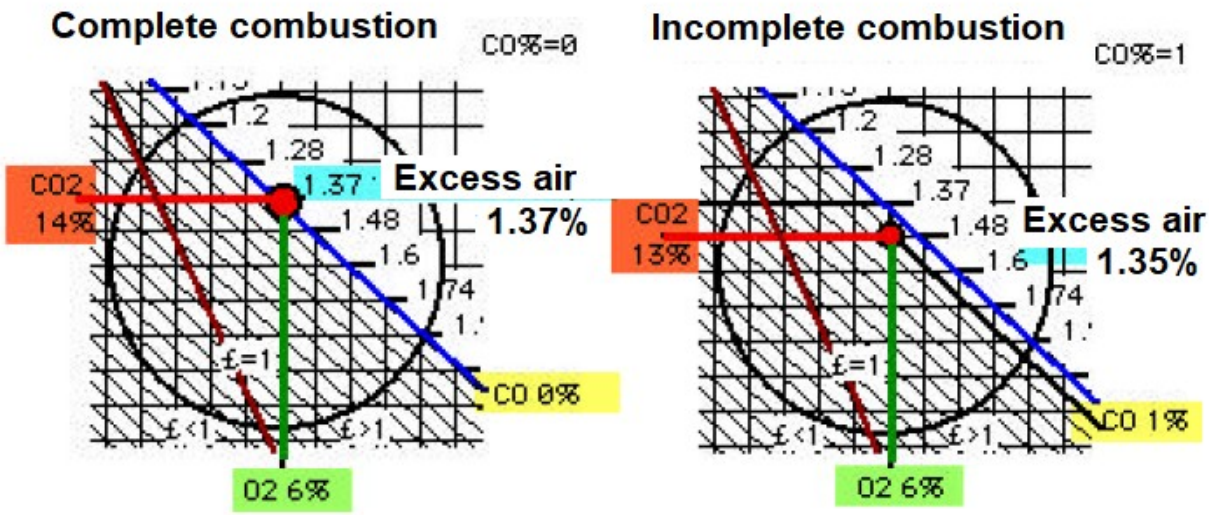
This leads to rapid fouling of the boiler (with an increase in the temperature of the exhaust gases and a decrease in the boiler's vaporization capacity).

One of the main causes of this condition is the moisture content of the wood (over 30%), which results in very cold secondary combustion and a longer combustion time in the firebox (reaching the end of the firebox without complete combustion).

Another cause is overloading the boiler, and since vaporization depends primarily on the secondary flame, heat transfer in the gasifier is minimal.

When the response is reduced for this reason, the boiler tends to overload to recover pressure. Under these conditions, the secondary combustion chamber is not large enough to allow sufficient time for combustion to complete, resulting in excess oxygen and unburned gases.

This characteristic requires the boiler operator to closely monitor steam consumption needs and anticipate these situations.



The graphs above (parts of an Ostwald triangle for wood) indicate the condition of complete combustion (CO=0%) and the condition where combustion is incomplete (CO%=1%), although with respect to O2 (oxygen).

In wood and gas boilers (such as natural gas), this results in very significant losses due to unburned gases (for every 1% of these gases measured in the chimney, more than 4% of the fuel can be lost through the chimney).